Rio Balsas most likely region for maize domestication

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In this issue of PNAS, two related articles researched and written by five scholars of early plant use, Piperno, Ranere, Holst, Iriarte, and Dickau, present long awaited data on early maize use in the heartland of its wild progenitor, the Rio Balsas area of Mexico. One, *Starch Grain and Phytolith Evidence for Early Ninth Millennium B.P. Maize from the Central Balsas River Valley, Mexico* (1), focuses on the microevidence for domestic plant use from tools and surrounding soils beginning ≈8700 B.P. The second paper, *Preceramic Human Occupation of the Central Balsas River Valley, Mexico: Cultural Context of Early Domesticated Maize and Squash* (2), provides the contextual information of the site and region from which these important data were uncovered. The strata, artifacts, sediments, and microbotanical evidence firmly points toward the domestication of both maize and squash occurring between 8,990 and 8,610 cal. B.P. in Mexico, perhaps even from that region of Mesoamerica, for these are the earliest dates yet recorded for maize. That these remains have been found in the ostensible homeland of the wild progenitor of maize further solidifies the thesis that this region in Guerrero was the probable locus of maize domestication.

The Geography of Zea

It is curious that with so much interest in the topic of plant domestication in archaeology, geography, and botany, it took until 2005 to include this region of Mexico in our search for the roots of domestication. This investigatory blind spot is most probably because visible early plant evidence was uncovered in dry conditions. Following the data, scholars pursued domestication where they could easily find the evidence, ignoring the regions where the interactions were more likely to occur. For years people have been looking in the higher, drier Mexican altiplano for evidence of maize domestication and early use, in part, because of the spectacular evidence uncovered in the Tehuacan caves and the Valley of Oaxaca by MacNeish and Flannery in the 1960s (3–5). Because of the beautiful sequence of maize cobs uncovered in the cave, models extended the evidence back in time, people pursued other locales in that region over the decades. Years earlier, the geographer Carl Sauer and his students suggested that early domestication should begin in seasonal wet and dry environments (6). The problem is these are regularly moist if not very wet environments, usually leaving no trace of major plant parts for archaeologists to easily uncover.

These authors, in their systematic pursuit of new approaches through microarchaeobotany, provide new data that now supports Sauer's thesis regarding domestication origins, at least for the case of maize and squash (1, 2). Their productive research strategy, in pursuit of long-term plant–human interaction, will allow archaeologists not only to fill in the gaps about the early processes of plant domestication, but also to link the moister regions to the drier areas, allowing us to contextualize the drier regions' histories where people had to navigate adopting the plants to different conditions.

Phytolith results corroborate the starch grain findings that teosinte was not exploited at Xihuatoxtla.

Once John Doebley's team (7, 8) identified the probable homeland of the *Zea mays* descendent, *Zea mays* ssp. *parviglumis* (teocinte), to be the Rio Balsas region of Mexico, it was clear that fieldwork in the region was the crucial next step required to understand the maize domestication story. Although many have been working on the mystery of maize domestication across both continents, it was not until this recent field research began in the Rio Balsas region that we were able to explicitly focus on the specific relation between teocinte and maize. The botanical paper (1), whose senior author is Piperno, applies new rigorous microbotanical identification procedures of both starch granules and interstitial phytolith silica bodies to artifacts and soil from the stratified cave with important results. The active, small, but growing group of microarchaebotanists have reached a plateau of identification methods and type collections that has allowed them to rigorously tackle these problems. Doubters continue to query the ancestry of maize (9), the early human interest in this tropical grass, the earliest uses, and the timing of its domestication process, but with studies like these, we will quickly narrow the key questions of maize.

The Tempo of Domestication

The botanical and anthropological issues surrounding maize have been exacerbated by the larger debates about the tempo of grain domestication in the larger palaeoethnobotanical literature. Whereas some scholars promote a quick morphological shift, over as little as one or two generations, triggered by intense human manipulation and style of harvest (10), others see gradual morphological changes in the plants extending up to thousands of years (11). These processes are linked to style of planting and harvesting, focusing on a range of selection pressures. So, it is with some anticipation that scholars await the results that are presented in the article *Starch Grain and Phytolith Evidence for Early Ninth Millennium B.P. Maize from the Central Balsas River Valley, Mexico* (1) concerning recent excavations at the Xihuatoxtla Shelter, located in the Central Balsas Valley, with an absolute date of 8,700 cal. B.P. What evidence do they present here for the selection pressures on maize, the domestication timing, and in turn the farming techniques that were practiced in this area at the time? Although this tropical region has not yielded macrobotanical maize remains, with the recent efforts by a range of scholars using both phytoliths and starch granules, more securely identifiable microbotanical remains have been found to be productive. Through this detailed methodological work, diagnostic taxa identifications of maize along two complimentary identification strategies took place. As outlined in Carl Sauer's thesis (6) many years ago these new data presented here reaffirm that this domestication process occurred in a midelevation, seasonal tropical forest, rather than in the semiarid highlands as has been proposed by scholars. Thus, these new data support the importance of a wet planting season for both maize and squash. Although they could have uncovered

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hints of teocinte in the shelter, they did not, suggesting that whatever selective pressures were placed on teocinte, by 8,700 B.P. this had already occurred. This evidence places the domestication process back further in time, still without concrete support for the mechanisms that triggered these results, and more importantly without information on the timing. Dorian Fuller's recent article (11) outlines a range of Eurasian food domestication processes, suggesting that different pressures influenced the timing of these processes. While the process has been pushed back in time for maize, we do not really have the first evidence for teocinte use by humans in the Rio Balsas area. We do know more about the type of farming, however, with evidence for burning to open up land along lake and river shores.

These low river valleys, between 700 and 1,800 m above sea level (asl), have distinct wet summers and dry winters, perfect for annual crops. This region is tropical deciduous forest with a diverse range of species. Nestled among small lakes and rivers, these karstically derived caves provide a congenial location for dwelling, with a broad range of plants and animals for food. One of these native species is the renowned teocinte, the progenitor of maize. Therefore, this region is important in our quest to learn about the odd evolution of maize and, equally importantly, the timing of early agriculture.

The phytolith and starch grain evidence presented here provides evidence that allows scholars to narrow the number of viable working hypotheses that exist in the literature concerning maize domestication. From a series of potential shelters, it was the Xihuatoxtla Shelter (964 m asl) that provided a long sequence of human occupation beginning in the early Holocene, between 10,000 and 7,500 B.P. This occupation sequence was laid down in five levels, each containing lithics, and the two upper levels contained ceramics demonstrating the long sequence of the shelter's use. The archaeological article (2) places this rock shelter in its regional picture that includes a series of shelters, each with slightly different subsistence evidence. The preceramic evidence in this diverse ecological region suggests that small groups moved around the countryside seasonally, beginning sometime in the ninth millennium, by farming along river and lake shores, with localized burning to expand the arable acreage. The research team has recorded early maize processing associated with dates as early as 6,500 B.P. Four of the grinding stones and two of the chipped stone tools with maize starch were located below a dated wood sample.

The phytolith results corroborate the starch grain findings that teosinte was not exploited at Xihuatoxtla, rather, the *Zea* remains are exclusively from maize cobs and kernels. No stalk phytoliths were identified, only cob phytoliths, reorienting our thinking back to an early focus on kernel consumption and its nutrients, rather than a focus on the stalk sap and its sweet flavor (12). Both phytolith size and morphology indicate a domesticated *Cucurbita* was present along with maize in the earliest preceramic occupations of the site. The squash micromeasurements also support domestic rinds rather than wild. These data imply that human selection for reduced lignification and silicification of squash fruits was underway by 8,700 cal. B.P.

Despite the doubters, the dual data analyses presented in these articles provides extra strength to the authors' conclusions as to region of domestication, production type, and perhaps most intriguing, the early value of maize: that of the grains and the carbohydrates, rather than the stalks and the sugars. These data provide new evidence for an increasingly specific location of domestication for a very important American plant food, allowing us to more firmly reorient the food and farming history back into the lowland river valleys while placing these processes more firmly in the early Holocene, almost identical to the Eurasian domestication time frame. This project has returned the focus to these lower, moister seasonal areas, where teocinte originated. In many ways this is not surprising, just previously overlooked. While this work does not answer all questions we have about maize domestication, it has refined our inquiry for this major American food in time and space.

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